FURTHER STUDIES OF THE READING-RECITATION PROCESS IN LEARNING

BY

E. B. SKAGGS
S. GROSSMAN
LOUISE KRUEGER
WM. C. F. KRUEGER

COLLEGE OF THE CITY OF DETROIT

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INTRODUCTORY STATEMENT

In this number of the Archives are brought together the results of three independent investigations of the problem of the optimal time for introducing the reading-recitation process in learning. The persons whose names appear at the head of each paper are responsible for their own work.

A brief final section has been added summarizing the experimental investigation up to the present time. This section was agreed upon and jointly written by the authors. A bibliography is appended to this section which brings the literature up to date.

The work reported by Louise Krueger was conducted under the direction of Professor F. N. Freeman at the University of Chicago. The other work reported in this volume was done in the Psychology Laboratory of the College of the City of Detroit.

The Authors.

Further Studies of the Reading-Recitation Process in Learning

CHAPTER I

THE OPTIMUM NUMBER OF READINGS BEFORE INTRODUCING READING-PROMPTING IN VERBATIM LEARNING

E. B. SKAGGS AND S. GROSSMAN

The investigation herein reported was carried out in order to secure further light upon the question: "What is the optimum number of readings before introducing the process of reading-prompting?" A considerable amount of work has already been reported on the general problem of reading and recitation. Gates,[1] in particular, has reported work bearing upon our specific problem. Inasmuch as his work dealt with children and mass methods it seemed very desirable to extend the investigation, using adult subjects who would give careful and detailed introspective reports.

The term "reading" is to be considered in a very strict sense. If one begins at the beginning of a series of nonsense syllables or a stanza of poetry and reads through with attention but with no attempt whatsoever at reconstructing the series, or testing one's self, we may speak of a "pure reading." Any deviation, however slight, from this rigid situation results in some sort of reading-prompting or reading-recitation. The subject must not anticipate the next word or syllable in a series but take each as it is given in the perception process of following the printed lines or following the spoken sounds. Whether any process is to be classed as a pure reading or not can only be determined by a study of the subject's introspections. As we wished a rigid control here we did not use any children in this investigation.

Ten subjects participated in the investigation. Eight were college upper-classmen who had had previous training in psychology. Two subjects, E.B.S. and I.D.S., were adults with

[1] Gates, A. I. "Recitation as a factor in memorizing." *Archives of Psychology*, 1917, No. 40.

a large background of training in past experiments in memory and in psychology in general. All of the subjects were interested in the experiment and we can say without hesitation that all subjects lived up to the instructions given to them in a most excellent manner.

Two forms of learning material were used, namely, nonsense syllables and poetry. Part I of this report deals with the work with nonsense syllables while Part II presents the work with poetry. Part I of the report is to be stressed and Part II is to be regarded as only suggestive due to the fact that only four subjects participated in the work.

Part I. Nonsense Syllables as Learning Material

A series of eight nonsense syllables was presented by means of a Shepard-Wirth exposure apparatus. When pure readings were being employed each syllable was presented for 1.4 seconds with 1.4 seconds intervening between the presentation of each syllable. Thus, in order to expose the whole series of syllables to the subject, 21 seconds were involved. The subject pronounced aloud each syllable as it came to view. He was under very strict instructions to make each reading a pure reading and not to permit himself to anticipate the next syllable in the slightest degree. At the end of each reading or reading-prompting a rest of one half minute was introduced, during which the subject relaxed and took a drowsy, passive attitude. In the following report a reading cycle will be referred to as R.

In the reading-prompting method the subject was instructed to try to recall the next syllable before it was shown. The first syllable of a series was always shown and then the experimenter waited for the subject to anticipate the next one. The subject was instructed to try to recall but not to "rack his brain" or spend much time if nothing promised to come. Unfortunately not all of our subjects took the same amount of time before giving up and asking for the syllable to be shown (the prompting). If the subject gave up and so expressed himself the next syllable was at once exposed at the exposure window. If, on the other hand, the subject was able to recall the next syllable it was shown promptly and the procedure continued. This process was continued until the subject could give one perfect recitation without any promptings. The

reading-anticipating-prompting procedure will henceforth be designated as RP.

Four different conditions or methods were employed and compared. In Method I the subject was shown the syllables just once, engaging in a straight reading, R. Then the RP procedure was introduced and this process was continued until the series was learned. In other words there was an initial R followed by RPs.

Method II involved three Rs before introducing the RPs. Method III involved five Rs before introducing the RP process. Method IV employed seven Rs before the RP process was introduced.

The different conditions or methods were rotated in the case of each subject in order to equalize practice effects and other influences which might tend to favor or hinder a given method.

Table I presents the averages for each of the three "trained subjects." The averages are based, in the case of each method, upon ten learnings or a total of 80 syllables. The figures represent the total learning time in seconds. The figures in parentheses represent the mean variations.

TABLE I
SHOWING RELATIVE LEARNING TIMES FOR FOUR METHODS

Subject	*Method I* *1 R*	*Method II* *3 R*	*Method III* *5 R*	*Method IV* *7 R*
E. B. S.	417	383	430.2	469.9
	(89.1)	(56.4)	(91.5)	(132.1)
S. G.	338.4	245.3	276.0	330.5
	(90.8)	(34.5)	(70.0)	(75.1)
S. C.	295.6	273	293	293.6
	(59)	(78.8)	(53)	(52.9)

Table II presents the total learning times for each of the four methods for five subjects. Table II could be combined with Table I for ordinary purposes, except for the fact that the averages are based upon only six experimental sittings instead of ten.

Assuming, as we have, that the total, actual time spent in learning is the most satisfactory criterion of efficiency in learning, then the above data are unusually clear-cut and decisive. In the case of six out of eight subjects Method II (3 preliminary readings) is the most efficient. In the case of the two exceptions Method III (5 preliminary readings) is the most efficient. *In no case is either Method I or Method IV the*

TABLE II

SHOWING RELATIVE LEARNING TIMES FOR FOUR METHODS

Subject	*Method I* *1 R*	*Method II* *2 R*	*Method III* *3 R*	*Method IV* *4 R*
E. S.	209.7	164.3	190.2	193.4
	(41.2)	(19.3)	(33.4)	(15.3)
Led.	292.1	302.6	262.8	317.3
	(91.2)	(48.8)	(56.1)	(65.0)
Hen.	410.5	363.0	295.5	412.3
	(89.2)	(69)	(60)	(57.1)
Law.	369	321.4	397.6	348.8
	(86.8)	(58.5)	(93.1)	(63.6)
Gro.	325.2	269.3	317.2	319.8
	(87.5)	(82.6)	(61.2)	(30.6)
Mean	321.3	284.1	292.7	318.3
Mean Variation	56.32	53.86	52.92	50.38

best. Likewise a study of the group averages indicates the same situation. In other words, one preliminary reading is not enough and seven preliminary readings are too many before introducing the RP process.

As no test was made of the relative efficiency of the four methods from the standpoint of retention or later recall, we have no direct evidence on this point. However, assuming that the time needed for the final successful recitation is a good index of *degree of learning* and, assuming further that retention is positively correlated with degree of original learning, we may gain some suggestions from the study of our data. If the reader disagrees with our assumptions the following figures are nevertheless valuable as indicating relative degrees of learning by the four methods. Table III presents the times taken for the final successful recall in the case of each method used.

Considered individually we note that five out of eight cases show a smallest average recitation time for Method II. A study of group averages indicates that Method II gives the shortest time and also the smallest mean variation. One can scarcely avoid the conclusion that the material is learned more thoroughly by Method II where three preliminary readings are involved. Now if one may infer better retention where learning is the strongest, one may assume that Method II is the best of the four methods from the standpoint of retention of the material.

The writers have worked with the number of Rs and RPs in the hope of discovering some mathematical expression of

TABLE III

SHOWING TIMES FOR FINAL SUCCESSFUL RECITATIONS

Subject	*Method I*	*Method II*	*Method III*	*Method IV*
E. B. S.	40.3	37.0	49.8	41.5
	(6.2)	(5.2)	(10.6)	(11.0)
S. G.	53.2	41.3	48.3	45.8
	(10.8)	(4.9)	(12.4)	(9.4)
S. C.	33.9	32.6	33.6	31.4
	(9.2)	(5.1)	(5.2)	(5.5)
E. S.	26.0	33.9	45.7	37.6
	(1.7)	(11.6)	(11.3)	(7.9)
Led.	27.8	24.5	27.3	29.0
	(4.2)	(4.0)	(4.4)	(6.3)
Hen.	32.6	27.6	27.6	31.0
	(4.3)	(4.3)	(3.0)	(5.0)
Law.	45.6	38.0	39.2	33.5
	(9.8)	(2.0)	(11.9)	(4.3)
Gro.	35.8	31.6	35.5	33.8
	(9.1)	(5.8)	(3.3)	(6.5)
Group Mean	36.9	33.3	38.3	35.4
M. V.	7.1	4.2	7.4	4.9

efficiency by such study. However, this hope has been abandoned excepting in so far as such study does indicate certain general relationships which may be valuable in other connections. For this reason and for the sake of completeness of report the average number of RPs for each method and for each subject are given in the following Table IV.

TABLE IV

SHOWING NUMBER OF RPS NEEDED TO LEARN BY EACH METHOD USED

Subject	*Method I* *1 R*	*Method II* *3 R*	*Method III* *5 R*	*Method IV* *7 R*
E. B. S.	6.4	5.2	4.9	5.1
	(1.5)	(0.8)	(0.92)	(1.5)
S. G.	4.5	3.2	2.8	3.1
	(1.0)	(0.81)	(0.8)	(0.9)
S. C.	5.9	4.4	4.1	3.3
	(1.6)	(0.8)	(0.8)	(0.8)
E. S.	3.8	2.3	1.7	1.2
	(0.8)	(0.4)	(0.4)	(0.3)
Led.	5.5	5.1	4.0	3.8
	(1.3)	(0.9)	(1.3)	(0.6)
Hen.	7.8	7.5	4.8	6.0
	(0.8)	(0.8)	(1.2)	(2.3)
Law.	6.8	5.2	5.6	4.0
	(1.4)	(1.4)	(1.3)	(1.0)
Gro.	5.3	3.9	3.7	3.8
	(1.8)	(1.1)	(0.7)	(0.6)
Mean of Group	5.75	4.60	3.95	3.80
M. V. of Group	0.98	1.20	0.91	0.94

A summary statement based upon Table IV is as follows:

1 preliminary R demands 5.75 RPs,
3 preliminary Rs demand 4.60 RPs,
5 preliminary Rs demand 3.95 RPs, and
7 preliminary Rs demand 3.80 RPs.

It is obvious that 7 readings are not 7 times as valuable as 1 reading—in fact, 7 readings are only about 1.5 more valuable than 1 reading in terms of the number of RPs needed to learn. In other words one notes a rapid onset of a law of diminishing returns as the number of preliminary readings is increased. With more extensive data one might work out a criterion of efficiency in terms of some ratio between the Rs and the RPs. This might be done by comparing these ratios with the time criterion of efficiency.

Suggestions Based upon the Subjects' Introspections

Inasmuch as careful and detailed introspections were taken chiefly to enable us properly to classify the Rs and RPs, no presentation of this mass of data will be presented. Whether or not an R was to be accepted as a pure R and so treated in our computations depended entirely upon the description given by the subject of just what he did in his mental processes. A few records which showed obvious testings or recalls during an R condition were eliminated and further records were secured in their place. However, our Tables present only *relatively* pure R values although no obviously improper R values are included. Further study of the introspective reports merely substantiated the facts reported in a previous investigation by the senior writer of this paper.[2] Several comments may be made which we believe are now thoroughly established on the basis of the subjects' verbal reports of their processes. In the first place a *pure reading* is a very rare thing, most difficult to secure. The reports indicate that there is nearly always a slight tendency to anticipate or test one's self. After the first reading about all that one can hope for from any subject is a "relatively" pure reading.

In the second place it is worthy to note that during the RP methods each subject reported that he felt that he was giving

[2] Skaggs, F. B. The relative value of grouped and interspersed recitations. *Jr. Exper. Psychol.*, 1920, 3, 424-46.

better attention. Also each subject felt conscious of a "self-activity" as contrasted with a feeling of passivity in the case of the readings. All investigators of the problem of reading-recitation have reported these facts.

Part II. Poetry as Learning Material

In spite of the fact that it is extremely difficult to control conditions in the case of sense-material the writers deemed it desirable to use such material. This part of our report presents a rather limited investigation in which poetry was used as the learning material.

The same four methods which were used and compared in Part I were likewise employed in this section. Each subject used his own rate in the learning of poetry, a fact that has introduced certain complications. Each subject was told clearly about our definition of "pure reading" and was asked to strive to attain the ideal when engaged in reading. All four subjects used in this experiment had memorized considerable poetry in the past. Subject RG had not had any regular psychological training.

The poetry which we used consisted of stanzas of Rossetti's poem, Rose Mary. As this is a very long poem one is able to select a sufficient number of stanzas for a fairly full testing of each method. The stanzas were of five lines each, thus permitting the subject to learn the piece in a fairly short time.

In the case of a "straight" R the subject began at the beginning of the stanza and read through to the end, reading aloud. He was under the instruction to avoid "looking back" or in any way testing himself. In the RP process the subject would try to say the stanza without looking at the verse but, if the next words would not come, he would look for the sensory cues from the page. The subject used his own rate of procedure. Ten or twelve stanzas were learned by each method, a number sufficiently large to bring about an equalizing of certain factors which we did not wish to enter into the comparative results.

Table V gives the average times required to learn by each method. The figures in parentheses are the mean variations. The total learning time does not, of course, include the half minute rest periods between the Rs or the RPs.

The first three subjects listed in the table show a greatest efficiency for Method II. This we found to be strikingly true

TABLE V
TOTAL TIME NEEDED FOR EACH METHOD OF LEARNING

Subject	*Method I* *1 R*	*Method II* *3 R*	*Method III* *5 R*	*Method IV* *7 R*
IDS	292.2	230	244	264.3
	(55.1)	(28.8)	(60.7)	(35.3)
EBS	377	312.5	451.4	450.3
	(72.5)	(50.2)	(100.4)	(99.0)
RG	191.3	182.6	202.3	190.1
	(35.7)	(64.4)	(60.3)	(49.5)
SG	191.8	211.2	188.8	234.6
	(98.4)	(91.2)	(44.5)	(63.0)

in the case of nonsense syllables. The data for SG are not very conclusive due to the large mean variations in the case of Methods I and II. Method III is his best method. It is significant that in no case is Method IV the most economical. The group averages are 252.3, 234.1, 271.6, and 284.8 seconds respectively for Methods I, II, III, and IV. Again Method II is the best.

Table VI presents the average times needed for the final successful recitation and so may be used as criteria of degree of learning.

TABLE VI
TIME NEEDED FOR FINAL SUCCESSFUL RECITATION

Subject	*Method I* *1 R*	*Method II* *3 R*	*Method III* *5 R*	*Method IV* *7 R*
IDS	24.6	20.7	21.2	23.7
EBS	38.0	33.3	39.0	33.0
RG	24.2	22.5	20.1	26.1
SG	21.2	29.5	28.4	22.4

The first two subjects listed show a shortest final recitation time for Method II. RG gives a shortest time for Method III. SG alone finds best results for Methods I and IV. In the case of three of the four subjects Methods I and IV are the poorest from the standpoint of degree of learning.

Table VII shows the number of RPs needed to give a perfect recitation or learning. The data indicate that: *increasing the readings from one to seven does not bring about a proportional saving of RPs.*

Some further comments upon the nature of the RP process:

It became evident that our four subjects were not using exactly the same method in the case of the RP process. EBS

TABLE VII

NUMBER OF RPS NECESSARY TO LEARN BY EACH METHOD

Subject	*Method I* 1 *R*	*Method II* 3 *R*	*Method III* 5 *R*	*Method IV* 7 *R*
IDS	8.3	7.4	5.6	4.5
EBS	8.5	6.1	7.0	6.8
RG	5.0	3.8	3.9	3.0
SG	5.2	3.9	3.5	3.6
Mean	6.8	5.3	5.0	4.5

spent much time trying to anticipate the next words or lines before he would resort to a "look" at the printed stanza. IDS spent very little time in this way, looking immediately when the word did not come to mind. EBS soon realized that he was using too much time trying to reconstruct the sentence but, having started with the method, he felt that he must keep on with it to the end. In other words *it is quite evident that one may spend too much time trying to recall* with the result that learning will be slow. The amount of time spent in the attempt to anticipate or recall should be controlled in an experiment of this kind. *There may be poor RP methods, indifferently good RP methods, and excellent RP methods.*

Lyon[3] says, "As a general rule it is best to memorize thoroughly before attempting recall. When in doubt do not waste time and form confusing associations by continuing the attempt, but consult the text immediately." Our own work would lead us to agree with the second statement of the quotation.

CONCLUSIONS

Our work has dealt with materials of relatively short length and we have not secured data on the relative retention efficiency of our four methods. We present the data from the work with nonsense syllables as fairly reliable whereas the data obtained from the work with poetry is only suggestive, due to the small number of subjects. With these facts in mind we may make the following statement of results of our investigation.

1. In the case of the nonsense syllables it was found most economical to introduce the reading-recitation process after

[3] Lyon, D. O. "Memory and the Learning Process." *Archives of Psychology*, 1916, No. 34, Page 153.

three preliminary readings. The same fact was indicated in the learning of poetry.

2. One preliminary reading is not sufficient whereas seven preliminary readings are too many from the standpoint of maximum efficiency as measured in actual learning time.

3. Using the time consumed in making the first successful recitation (our definition of learning) as the criterion of degree of learning, three preliminary readings resulted in the greatest degree of learning.

4. After one reading it is extremely difficult to secure "pure readings." Each subject tends to anticipate, to however small a degree, the next item in the series.

5. If left to their own devices subjects will differ greatly in the amount of time that they devote to an attempt at recalling an item before they give up and receive a prompting. It is an interesting problem for future investigation to determine how much time or effort should be spent by the learner in the anticipation process.

CHAPTER II

THE RELATIVE EFFECT OF INTERSPERSING A RECALL AT DIFFERENT STAGES OF LEARNING

LOUISE OLSON KRUEGER

This experiment was designed to study (1) the form of the learning curve when no recall was interspersed during the learning period, (2) the effect of inserting a recall during the early part of the learning process, and (3) the effect of introducing a recall late in the learning period.

Progress in learning is largely due to (1) repetition of an act and (2) elimination of errors. In ideational learning, mere repetition, such as continuous reading, gives opportunity to form associations between successive items of the material presented for learning, while recall is helpful in discovering errors and shortening the learning time. The purpose of this investigation is to study experimentally the effect of mere repetition upon the progress of learning and the effect of inserting one recall during the various stages of the learning process. The study is limited to various combinations of presentations and presentations with a recall interspersed, with the total number of presentations ranging from two to ten.

The learning material consisted of 20 series of pairs of logically unrelated monosyllabic nouns. Each learning series contained 20 pairs of words, each pair having been typewritten on a 3 x 5 card. The corresponding recall series was made up of the first word of each pair, one word typed to a card. The stimulus words on the recall cards were arranged in a different order from those of the learning series. The nouns were chosen at random from Webster's Dictionary. The criteria for constructing the pairs of words were that no two members of a pair should be logically related, or similar in structure and sound. The twenty subjects were graduate students, most of whom were enrolled in the School of Education of the University of Chicago.

During the learning period, the list of pairs of words was presented by means of cards flashed at the rate of two seconds per card. In order to test the degree of learning, the stimulus

words were presented alone and at the rate of two seconds per word. The subject was to make a verbal response within two seconds. No promptings were given, and only correct answers were scored. The number of correct responses was the score for the amount of learning. Learning was tested immediately after the specified number and arrangements of presentations had been given.

Fifteen arrangements of learning were used, as shown by Table I, in which L means one presentation and R means a recall by verbal report. The last recall furnished the learning score for each respective arrangement. Only one series was learned on any one day.

Table II gives the order of procedure for each subject during his part of the experiment. The second row shows the respective conditions of learning. The Roman numerals of the first column represent the twenty subjects. The Arabic numerals in all other columns refer to the number of the learning series used for each arrangement. All subjects were required to learn four practice lists before beginning the main experiment in order to familiarize themselves with the procedure, and also to eliminate the initial practice effect.

To equalize further possible practice effect, the odd-numbered subjects proceeded to learn the lists in the order from left to right, while the even-numbered subjects learned the lists in the opposite order, or from right to left. For example,

TABLE I
ARRANGEMENTS OF LEARNING

Number	*Arrangement*	*Reason for Arrangement*
A	2L-R	To determine the shape of the learning curve when no recall was interspersed during the learning period
B	4L-R	
C	6L-R	
D	8L-R	
E	10L-R	
F	2L-R—2L-R	To insert one recall during the early part of the learning period
G	2L-R—4L-R	
H	2L-R—6L-R	
I	2L-R—8L-R	
J	4L-R—2L-R	To insert one recall during the late part of the learning period
K	6L-R—2L-R	
L	8L-R—2L-R	
M	4L-R—4L-R	To insert one recall near the middle of the learning process
N	6L-R—4L-R	
O	4L-R—6L-R	

TABLE II
ORDER OF LEARNING PROCEDURE

Subject	*Order of Arrangements*														
	C	*A*	*E*	*B*	*D*	*F*	*I*	*L*	*J*	*N*	*G*	*K*	*H*	*M*	*O*
I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
II	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
III	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
IV	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
V	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
VI	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
VII	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1
VIII	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2
IX	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3
X	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4
XI	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5
XII	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6
XIII	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7
XIV	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8
XV	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9
XVI	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10
XVII	17	18	19	20	1	2	3	4	5	6	7	8	9	10	11
XVIII	18	19	20	1	2	3	4	5	6	7	8	9	10	11	12
XIX	19	20	1	2	3	4	5	6	7	8	9	10	11	12	13
XX	20	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Subject I started to learn with Series 1 for Arrangement C; then he learned List 2 for Arrangement A; next he proceeded with List 3 for Arrangement E, etc. Subject II started with List 16 for Arrangement O; then he learned List 15 for Arrangement M; next he learned List 14 for Arrangement H, etc. Thus the same group of twenty subjects was utilized for each of the fifteen arrangements of learning, but they were presented a different list of words for each arrangement. The average learning score for each arrangement is based upon the learning scores from twenty subjects, each of whom learned a different list. A typewritten copy of the following *"Directions for the Subject"* was read by each subject before he started the experiment.

Directions for the Subject

This experiment is concerned with a "learning problem." The experimenter will present to you on flashed cards a list of pairs of words. You are asked to memorize these pairs of words so that when the first word of a pair is given alone, you may name the second member of the pair. After the list has been presented several times, you will be asked to recall the second word when the first word is presented alone. If you cannot recall the corerct word, you may give any word that comes into your mind, even though you are not certain of its accuracy. Sometimes you may be asked to give a second re-

Table III

Individual Learning Scores for All Arrangements

Subjects	6L-R C	2L-R A	10L-R E	4L-R B	8L-R D	2L-R—2L-R F	2L-R—8L-R I	8L-R—2L-R L	4L-R—2L-R J	6L-R—4L-R N	2L-R—4L-R G	6L-R—2L-R K	2L-R—6L-R H	4L-R—4L-R M	4L-R—6L-R O
I	10	5	14	6	12	13	14	14	14	14	10	16	11	13	15
II	8	4	9	4	7	6	8	9	7	9	7	8	6	7	8
III	5	3	6	6	5	6	7	8	6	8	6	8	7	8	9
IV	8	7	10	8	7	12	12	15	8	11	12	13	14	13	13
V	9	2	6	5	11	11	13	9	13	11	11	11	10	12	13
VI	11	5	10	6	9	8	11	10	9	12	10	12	10	10	11
VII	9	5	9	8	10	8	10	11	10	11	8	14	9	12	9
VIII	8	4	8	7	11	10	13	13	14	16	11	12	13	9	13
IX	12	9	14	8	12	12	15	14	14	17	13	14	14	12	14
X	9	6	8	8	10	10	11	12	11	14	10	11	12	11	11
XI	13	5	15	9	13	12	16	17	15	17	14	14	13	15	17
XII	9	6	9	6	8	9	12	12	11	12	10	13	12	11	13
XIII	9	5	12	7	11	9	11	14	9	15	9	10	12	9	12
XIV	8	6	13	8	10	8	10	13	11	12	9	14	13	12	10
XV	10	5	7	8	9	7	9	10	11	13	12	12	14	11	13
XVI	11	4	9	9	11	9	12	14	10	15	12	13	13	13	12
XVII	10	7	10	9	11	8	14	13	12	12	9	13	12	13	12
XVIII	11	5	14	8	14	11	13	14	13	14	10	14	13	14	15
XIX	6	5	7	5	8	7	10	13	10	12	12	9	8	8	9
XX	12	7	8	10	12	10	14	16	12	16	11	15	9	11	15

call. The experimenter will always tell you when a recall is desired.

Do not write down the words, nor attempt to recall them after you have finished the work in the laboratory. I am not interested in individual performances. I want group results. Please do not discuss this experiment with others.

I appreciate the courtesy of your assistance throughout the experiment.

Results

In Table III are found the respective learning scores of the 20 subjects for the various arrangements of learning as outlined in Table II. Table IV gives the average learning scores for all arrangements with their respective two measures of variability, the S.D.'s and P.E.'s. By inspection it may be seen that the average learning scores are fairly reliable. The quotients of reliability of the difference between two obtained means are given in Table V. Only such comparisons were chosen as had bearing upon our problems.

(1) Curve A represents the learning curve for arrangements A (2L-R), B (4L-R), C (6L-R), D (8L-R), and E (10L-R), when no recall was introduced during the learning process. The curve ascends rapidly as the number of presentations was increased from two to four and to six. A slight increase was obtained with eight presentations, while ten presentations gave a slight decline over eight. The differences between the means for Arrangements A and B, B and C, are

Table IV

Average Learning Scores for the Various Arrangements

Arrangement	*Average*	*S.D.*	*P.E.*
A 2L-R	5.25	1.5124	.2281
B 4L-R	7.25	1.5452	.2330
C 6L-R	9.40	1.9340	.2916
D 8L-R	10.05	2.1790	.3286
E 10L-R	9.90	2.7550	.4155
F 2L-R—2L-R	9.30	2.0267	.3056
G 2L-R—4L-R	10.30	1.9261	.2905
H 2L-R—6L-R	11.25	2.3425	.3532
I 2L-R—8L-R	11.75	2.2776	.3435
J 4L-R—2L-R	11.00	2.3874	.3600
K 6L-R—2L-R	12.30	2.1703	.3273
L 8L-R—2L-R	12.55	2.3553	.3552
M 4L-R—4L-R	11.20	2.0881	.3149
N 6L-R—4L-R	13.05	2.4387	.3678
O 4L-R—6L-R	12.20	2.3367	.3524

TABLE V

COEFFICIENTS OF RELIABILITY OF DIFFERENCE BETWEEN TWO MEANS*

Two Arrangements to be Compared	*Quotient of Reliability*
A {2L-R / 4L-R} and B	6.13
B {4L-R / 6L-R} and C	5.76
C {6L-R / 8L-R} and D	1.48
D {8L-R / 10L-R} and E	.28
F {2L-R—2L-R / 2L-R—4L-R} and G	2.37
G {2L-R—4L-R / 2L-R—6L-R} and H	2.03
H {2L-R—6L-R / 2L-R—8L-R} and I	1.01
F {2L-R—2L-R / 4L-R—2L-R} and J	3.60
J {4L-R—2L-R / 6L-R—2L-R} and K	2.67
K {6L-R—2L-R / 8L-R—2L-R} and L	.52
B {4L-R / 2L-R—2L-R} and F	5.33
C {6L-R / 2L-R—4L-R} and G	2.19
C {6L-R / 4L-R—2L-R} and J	3.45
G {2L-R—4L-R / 4L-R—2L-R} and J	1.51
D {8L-R / 2L-R—6L-R} and H	2.49
D {8L-R) / 6L-R—2L-R} and K	4.85
D {8L-R / 4L-R—4L-R} and M	2.53
H {2L-R—6L-R / 4L-R—4L-R} and M	.01
K {6L-R—2L-R / 4L-R—4L-R} and M	2.42
H {2L-R—6L-R / 6L-R—2L-R} and K	2.18
E {10L-R / 2L-R—8L-R} and I	3.43
I {2L-R—8L-R / 4L-R—6L-R} and O	.91
O {4L-R—6L-R / 8L-R—2L-R} and L	.70
L {8L-R—2L-R / 6L-R—4L-R} and N	.98
I {2L-R—8L-R / 8L-R—2L-R} and L	1.62
N {6L-R—4L-R / 4L-R—6L-R} and O	1.67

*Calculated by means of formula $\frac{D}{P.\ E.\ (diff.)}$

The three learning curves, based upon the data of this experiment, are plotted in Figure I.

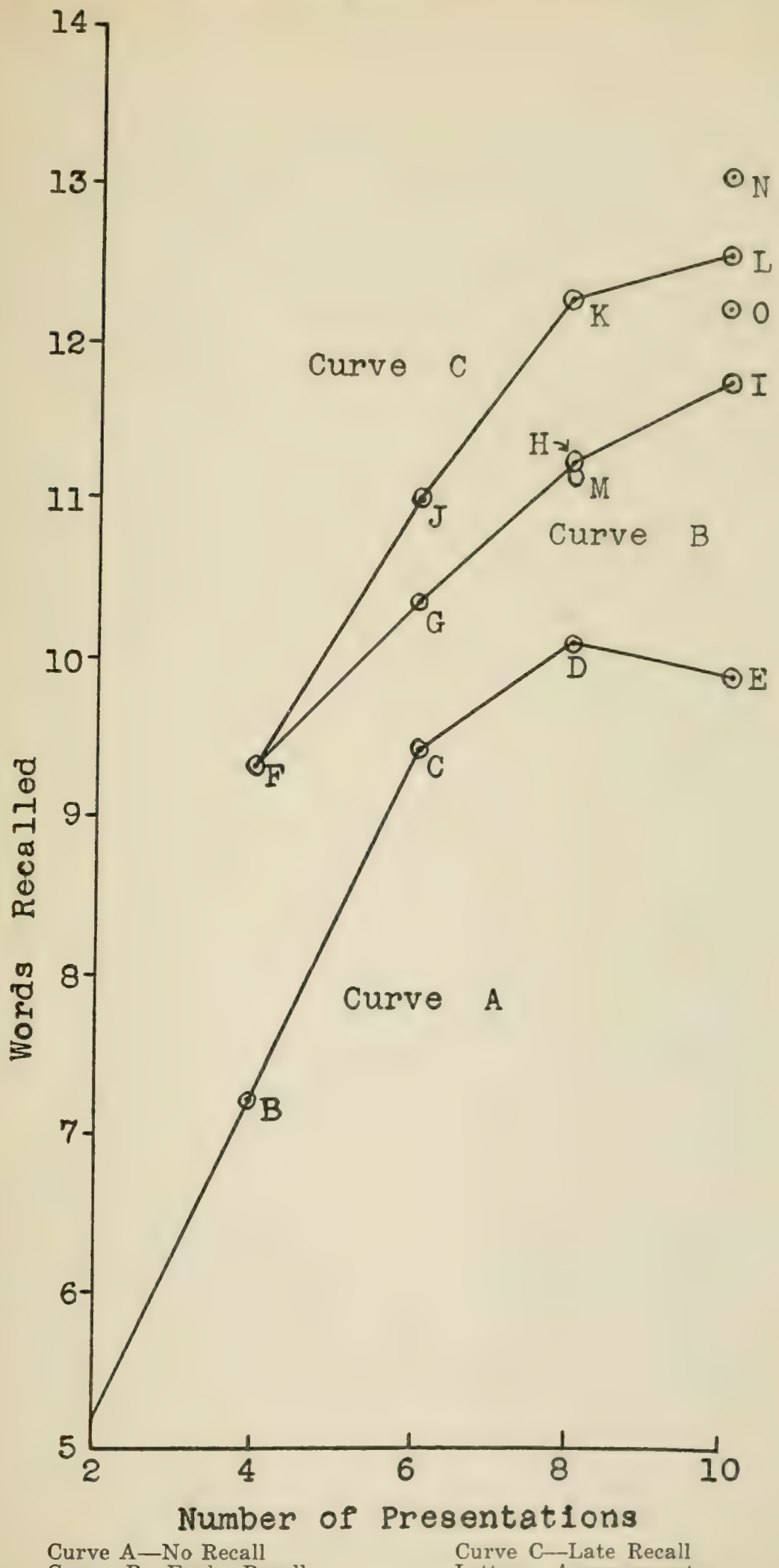

FIG. 1. LEARNING CURVES SHOWING RELATIVE EFFECTIVENESS OF RECALL.

statistically reliable, while the difference between averages for C and D is less reliable, and the difference between means for D and E is of no statistical significance. We may interpret these findings as an indication that with our materials and arrangements of learning, an optimal number of six presentations gave the most economical results. Presentations beyond the optimal of six increased learning very little. Apparently our results coincide with those of Miss Obershelp[4] who employed lists of approximately the same length and content as ours. She found that learning progressed very little after an optimal of six trials had been reached. Witasek,[5] whose subjects learned series of ten pairs of nonsense syllables, concluded that for his conditions learning progressed very little beyond eleven presentations when no recall was inserted during the learning process.

(2) Curve B is the learning curve for Arrangements F (2L-R-2L-R), G (2L-R-4L-R), H (2L-R-6L-R), and I (2L-R-8L-R) when one recall was inserted after the initial two presentations of the material. As the total number of presentations was increased from four to ten, by steps of two, the corresponding learning scores also increased consistently. The differences between the average learning scores for Arrangements G and H are considerably reliable and significant from the standpoint of indicating an important increase in the amounts learned. The difference between means for Arrangements H and I is somewhat more than that of chance. This phenomenon may be due to the fact that an optimal of six presentations was exceeded in the last eight trials of Arrangement I. A second recall inserted after a total of eight presentations might have considerably increased this learning score.

(3) In Curve C we have plotted the learning scores for Arrangements F (2L-R-2L-R), J (4L-R-2L-R), K (6L-R-2L-R), and L (8L-R-2L-R) in which the recall was interspersed before the last two presentations. Again the data show a continuous increment in the learning scores as the total number of trials was increased from four to six, to eight, and to ten. The differences between the averages for Arrangements F and J, and J and K are large enough to have noteworthy statistical

[4] Obershelp, Vera. "Influence of Context on Recall with Varying Degrees of Learning." Unpublished Master's Thesis, University of Chicago.

[5] Gates, A. J. "Recitation as a Factor in Memorizing." *Archives of Psychology*, 1917, No. 40.

reliability. However, the difference between means for Arrangements K and L is not so pronounced.

(4) A comparison of Curve A (when no recall was introduced in the learning process) with Curves B and C (when one recall was inserted during the learning period) brought out the fact that a recall was always beneficial in that it increased the learning scores when the total number of trials was the same.

(5) When comparing Curve B (an early recall inserted) with Curve C (a late recall introduced) it was found that a late recall consistently gave a higher learning score than an early recall for all combinations in which the total number of trials was the same. While the differences between the means for Arrangements G and J, H and K, I and L were never of unquestionable statistical reliability, the differences were consistent, and the condition with the late recall always yielded the higher learning score.

It is to be noted that the introduction of one recall postponed the drop in Curves B and C when the total number of trials was ten. Whether additional trials would have caused a continued rise in the two curves is problematical.

It was also of interest to make a comparison of the various arrangements in which the total number of trials was alike.

(6) Arrangements B and F had four presentations each, but a recall was inserted for Arrangement F. The latter arrangement has the higher learning score, and the difference between the averages was sufficiently large to make it reliable.

(7) The total number of presentations for Arrangement C, G, and J was six. From these data and with these conditions of learning it may be concluded that (1) the learning score was increased by the introduction of a recall, and (2) the late recall yielded a higher average learning score than the early recall. The differences between the averages are fairly reliable.

(8) A comparison was also made of the combinations of learning which had a total of eight presentations. These were Arrangements D, H, M, and K. In these conditions there was a tendency for the learning score to increase as the recall was delayed. There was one exception, namely Arrangement M, in which the recall came at the mid-point of the learning process and which yielded a slightly lower score than Arrangement

H, but a decidedly lower score than Arrangement K. Since the actual differences between means for Arrangements D, H, M, and K were not very decisive, this one irregularity might disappear if a larger number of subjects were used.

(9) A comparison of Arrangements E, I, L, N, and O, in which the total number of presentations was ten, likewise indicated that under the conditions of this experiment, there was a tendency to yield increasingly larger scores as the recall was delayed. The fact that Arrangement N had a higher average score than Arrangement L may be explained on the basis that very little additional learning took place after the optimal of six trials had been reached. In Arrangement L, the optimal number of presentations was exceeded before the first recall was inserted, while in Arrangement N the optimal was reached at the time the first recall was made. One could expect a larger learning score for Arrangement N than for Arrangement L since the subjects were given four rather than two learning trials after the first recall. A comparison of the average for Arrangement E with the means for the other arrangements showed significant and reliable differences, but the differences between the means for Arrangements I, L, N, and O are not very pronounced.

Other conditions being equal, the most favorable place to insert a recall was immediately after the optimal number of presentations.

Individual differences.—Individual differences may be summarized under three points as follows: (1) Those subjects who in comparison with other subjects had relatively high learning scores, maintained high scores irrespective of arrangement of learning. Those subjects with relatively low scores, had low scores throughout. (2) When the total number of presentations was the same for any two arrangements of learning, only two subjects had the higher score with the early recall in the majority of comparisons. (3) When the total number of trials was the same for any two arrangements of learning, fifteen subjects had the higher learning score with the late recall in the majority of comparisons.

Introspective reports.—Most of the subjects said that they seemed to lose interest in the task when the number of presentations exceeded six successive trials before the first recall was given. Since the subjects never knew which arrangement

was to be used, surprise was usually expressed whenever the first recall was inserted after two presentations. Then the subjects would frequently increase their efforts to learn the material, especially if the score was low.

Low scores were attributed by the subjects to (1) lack of interest after a certain number of presentations, (2) fatigue caused by previous class room work, (3) emotional disturbances of various kinds acquired either before or during the learning period, (4) lack of sleep, and (5) inhibitions due to other problems impinging upon their attention.

Some subjects preferred to learn the lists by rote memory, others by various groupings of words through immediate associations. Three or four subjects concentrated upon two or three pairs of words and, after having learned these, they proceeded to master two or three other pairs, and so on during the period of presentation of the material.

The various lists seemed of equal difficulty to the subjects. This subjective estimate is substantiated by an actual calculation of the number of words recalled for each list for all fifteen conditions in which the lists were used. The average number of words recalled ranged from 9.33 to 11.49, with a final average of 10.46 words for all lists and for all conditions.

Conclusions

From the experimental data obtained under the conditions of this experiment the following conclusions were made:

(1) Successive presentations of the material increased the learning up to an optimal number of trials. After this optimal number of six presentations, additional presentations did not yield any increase in the learning score. In our experiment, the largest number of presentations did not always give the highest learning score.

(2) A recall inserted during the learning period was always beneficial regardless of the time of its introduction into the learning period.

(3) A recall inserted during the latter half of the learning period was more beneficial than a recall introduced during the first half.

(4) A recall inserted immediately after the optimal number of presentations gave the highest learning score, other conditions being equal.

CHAPTER III

THE OPTIMAL EFFECT OF A RECALL DURING LEARNING

WM. C. F. KRUEGER

The present experiment was suggested by problems in the preceding study.

(1) If the number of presentations is increased and no recitation is introduced, will the corresponding recall scores increase, remain constant, or decrease?

(2) Does an interpolated recall increase the retention score irrespective of when it is introduced during the learning process?

(3) Will the effectiveness of one interspersed recall vary with the stage of learning at which it is inserted?

(4) Is an early recall more economical than a late recall when the total number of presentations is constant?

(5) What seems to be an optimal number of presentations before introducing the first recall?

The reader will note the similarity of general procedure in the preceding and the present study. The conditions of learning and the general plan in this study differ from, or are alike to those of the preceding experiment in the following respects:

(1) Instead of fifteen conditions of learning we used twenty-seven arrangements as shown in Table I.

TABLE I

ARRANGEMENTS OF LEARNING

4L-R*	4L-R—4L-R
6L-R	4L-R—6L-R
8L-R	4L-R—8L-R
10L-R	4L-R—10L-R
12L-R	6L-R—2L-R
14L-R	6L-R—4L-R
	6L-R—6L-R
2L-R—2L-R	6L-R—8L-R
2L-R—4L-R	8L-R—2L-R
2L-R—6L-R	8L-R—4L-R
2L-R—8L-R	8L-R—6L-R
2L-R—10L-R	10L-R—2L-R
2L-R—12L-R	10L-R—4L-R
4L-R—2L-R	12L-R—2L-R

*L refers to presentation of the list for learning.
R refers to interpolated or final recall.

(2) In addition to four practice lists, we selected nine lists of twenty pairs of monosyllabic nouns. Each list was constructed with these criteria in view: (a) no pair of words was to be logically related, (b) the two words were not to be similar in sound or structure. The experimenter considered the lists used in this study easier than those lists employed previously.

(3) The subject was presented with a list of twenty pairs of words for the number of presentations required by the respective arrangement of learning. Each pair of associates was shown on small cards for two seconds, in the same manner as before.

(4) Learning was measured as in the previous study. The score was the number of correct responses given during the last recall. The first word of each pair was used as a stimulus word, and the subject was to supply the corresponding associate. The order of the stimulus words differed from the order of presentation of the pairs of associates. Instead of oral recall we used written recall. The subject was given two seconds to write down the answer. If he did not start to write before the two seconds were up, the response was not counted. The recall series was presented at the rate of two seconds for each word, no extra time being allowed for any reason. No responses were counted unless started or finished during the respective time limit for that particular stimulus word.

(5) Only one list was learned on any one day.

(6) Each subject practiced on three or four lists before learning the nine lists selected for the present data.

(7) A set of instructions and explanation was given as before.

(8) Instead of having the one hundred and eight subjects learn twenty-seven different lists for the twenty-seven different arrangements of learning, we used the following method. (a) One group of thirty-six subjects learned the nine lists for the arrangements as indicated in Series 1 of Table II. (b) Another group of thirty-six subjects proceeded in like manner with Series 2. (c) A third group of thirty-six subjects did the same for Series 3. (d) One-half of each group learned the lists for the arrangements in the order from top to bottom, while the other half of the groups learned in the order of the arrangements from bottom to top. (e) By this method we

obtained four scores from each of the nine lists used, or a total of thirty-six scores for each condition of learning.

TABLE II
CONDITIONS OF LEARNING FOR THE THREE GROUPS OF SUBJECTS

Series 1	*Series 2*	*Series 3*
4L-R—2L-R	4L-R—6L-R	6L-R—4L-R
6L-R—6L-R	6L-R—2L-R	8L-R—4L-R
8L-R—2L-R	2L-R—8L-R	4L-R—4L-R
8L-R	14L-R	10L-R
2L-R—10L-R	10L-R—2L-R	6L-R—8L-R
12L-R—2L-R	2L-R—12L-R	4L-R—8L-R
4L-R	12L-R	6L-R
8L-R—4L-R	2L-R—6L-R	2L-R—4L-R
10L-R—4L-R	2L-R—2L-R	4L-R—10L-R

(9) In the estimation of the experimenter the three groups were well equated, with little possibility that differences in scores were due to different learning abilities of the three groups.

(10) The subjects were undergraduate college students.

RESULTS

The average recall scores as tabulated in Table III are based on thirty-six scores, or four scores from each of the nine lists. The respective measures of variability, the Standard Deviation and the Probable Error, for each mean indicate that the averages are reliable and consistent for each of the twenty-seven conditions of learning. We grouped the means arbitrarily on the bases of frequency of presentation of the list, and the stage of learning at which the first recall was made. Thus the last average in each group is for that condition in which no extra recall was inserted. We also calculated the Quotient of Reliability for the difference between two means within each group. We used the formula $\frac{D}{\text{P.E. (diff.)}}$ in which D refers to the absolute difference between the two selected means, and P.E.(diff.) refers to the Probable Error of the Difference.[6]

Table IV contains such quotients as we deemed necessary for interpretation of the data. The first column refers to the two conditions of learning; the second column states the actual difference between these two means as determined from Table

[6] William S. Foster. *Experiments in Psychology*, pp. 77-9. New York: Henry Holt & Co., 1923.

TABLE III
AVERAGE RECALL SCORES FOR ALL ARRANGEMENTS OF LEARNING

Total Presentations	*Arrangements of Learning*	*Av. Number of Words Recalled*	*S. D. of Recall Score*	*P. E. of Recall Score*
4	2L-R—2L-R	8.22	3.08	.34
4	4L-R	5.69	1.71	.20
6	2L-R—4L-R	9.19	3.04	.34
6	4L-R—2L-R	9.80	3.02	.34
6	6L-R	8.42	2.72	.30
8	2L-R—6L-R	10.64	3.13	.35
8	4L-R—4L-R	11.10	3.03	.34
8	6L-R—2L-R	11.27	3.82	.43
8	8L-R	9.44	3.48	.39
10	2L-R—8L-R	10.66	3.48	.39
10	4L-R—6L-R	12.55	3.75	.42
10	6L-R—4L-R	12.14	3.19	.35
10	8L-R—2L-R	12.06	4.04	.45
10	10L-R	9.25	2.74	.30
12	2L-R—10L-R	11.69	3.17	.36
12	4L-R—8L-R	12.72	3.69	.41
12	6L-R—6L-R	12.63	3.60	.40
12	8L-R—4L-R	13.30	2.88	.36
12	10L-R—2L-R	11.75	3.10	.35
12	12L-R	9.61	3.48	.39
14	2L-R—12L-R	10.94	3.16	.35
14	4L-R—10L-R	13.05	3.29	.37
14	6L-R—8L-R	13.55	3.31	.37
14	8L-R—6L-R	14.39	2.85	.32
14	10L-R—4L-R	13.47	3.18	.36
14	12L-R—2L-R	11.50	4.06	.46
14	14L-R	9.39	4.15	.46

III; the next column shows the respective quotients of reliability; the last column indicates the chances that the difference between the two respective averages represents a true difference in 100 cases.

The data as tabulated in Table III show clearly that if the number of presentations was increased and no recall was interspersed, the recall scores increased consistently until an optimal of eight presentations was attained. After this optimal number of presentations, additional presentations did not increase the recall scores. Arrangement 6L-R had a larger recall score than Arrangement 4L-R and the difference between the respective means is statistically valid. (See Table IV.) Arrangement 8L-R showed an increase in recall score over Arrangement 6L-R, but the reliability of the difference between the two respective means was not as high as the pre-

TABLE IV

COEFFICIENTS OF RELIABILITY BETWEEN TWO MEANS

Two Arrangements to be Compared	*Absolute Difference between two resp. means*	*P. E. (diff.) for the two means*	*Coefficient of Reliability*	*Chances of a true difference in 100*
4L-R and 6L-R	.73	.36	7.58	100
6L-R and 8L-R	1.02	.49	2.08	92
8L-R and 10L-R	.19	.49	.41	60
10L-R and 12L-R	.36	.49	.74	69
12L-R and 14L-R	.22	.60	.37	59
4L-R and 2L-R— 2L-R	2.53	.39	6.49	100
6L-R and 2L-R— 4L-R	.77	.45	1.71	87
6L-R and 4L-R— 2L-R	1.38	.45	3.07	98
8L-R and 2L-R— 6L-R	1.20	.53	2.26	93
8L-R and 4L-R— 4L-R	1.66	.52	3.20	98
8L-R and 6L-R— 2L-R	1.83	.53	3.45	99
10L-R and 2L-R— 8L-R	1.41	.49	2.88	97
10L-R and 4L-R— 6L-R	3.30	.52	6.34	100
10L-R and 6L-R— 4L-R	2.89	.46	6.28	100
10L-R and 8L-R— 2L-R	2.81	.54	5.20	100
12L-R and 2L-R—10L-R	2.08	.53	3.92	100
12L-R and 4L-R— 8L-R	3.11	.57	5.46	100
12L-R and 6L-R— 6L-R	3.02	.56	5.39	100
12L-R and 8L-R— 4L-R	3.69	.53	6.96	100
12L-R and 10L-R— 2L-R	2.08	.52	4.11	100
14L-R and 2L-R—12L-R	1.55	.58	2.67	97
14L-R and 4L-R—10L-R	3.66	.59	6.20	100
14L-R and 6L-R— 8L-R	4.16	.59	7.05	100
14L-R and 8L-R— 6L-R	5.00	.56	8.91	100
14L-R and 10L-R— 4L-R	4.08	.58	7.04	100
14L-R and 12L-R— 2L-R	2.11	.65	3.25	99
2L-R— 4L-R and 4L-R— 2L-R	.61	.48	1.27	81
2L-R— 6L-R and 6L-R— 2L-R	.63	.54	1.16	79
2L-R— 8L-R and 8L-R— 2L-R	1.40	.60	2.33	94
4L-R— 6L-R and 6L-R— 4L-R	.41	.54	.76	69
2L-R—10L-R and 10L-R— 2L-R	.06	.50	.12	53
4L-R— 8L-R and 8L-R— 4L-R	.58	.54	1.08	77
2L-R—12L-R and 12L-R— 2L-R	.56	.58	.96	74
4L-R—10L-R and 10L-R— 4L-R	.42	.54	.79	71
8L-R— 6L-R and 6L-R— 8L-R	.84	.49	1.71	87
2L-R— 6L-R and 4L-R— 4L-R	.46	.49	.94	74
4L-R— 4L-R and 6L-R— 2L-R	.17	.55	.30	58
2L-R— 8L-R and 4L-R— 6L-R	1.89	.62	3.05	98
6L-R— 4L-R and 8L-R— 2L-R	.08	.53	.16	54
2L-R—10L-R and 4L-R— 8L-R	1.03	.55	1.87	89
4L-R— 8L-R and 6L-R— 6L-R	.09	.57	.16	53
6L-R— 6L-R and 8L-R— 4L-R	.67	.54	1.24	80
8L-R— 4L-R and 10L-R— 2L-R	1.55	.50	3.10	98
2L-R—12L-R and 4L-R—10L-R	2.11	.51	4.16	100
4L-R—10L-R and 6L-R— 8L-R	.50	.53	.95	74
8L-R— 6L-R and 10L-R— 4L-R	.92	.48	1.91	90
10L-R— 4L-R and 12L-R— 2L-R	1.97	.65	3.34	99

vious comparison. Further increases in the number of presentations did not increase the corresponding average final scores to

any degree of significance. The differences between the means for 10L-R, or 12L-R, or 14L-R and the average for 8L-R were very small and had little or no statistical value. The experimental findings in this study agree remarkably with those in the preceding experiment. It may be said that eight successive presentations rather than six continuous trials furnished an optimal after which additional presentations added little or nothing to the recall scores. This difference may have been due to the difference in the learning material, the latter lists being considered easier than those used in the earlier study.

The data also show that an interpolated recall increased the recall score irrespective of when the recall was introduced in the learning process. Whenever the total number of presentations of the learning material was constant, every condition with an interpolated recall had a respectively higher score than the condition without such interspersed recall. This held true for all comparisons without a single exception. The difference between a mean for a condition without the interspersed recall and the mean for a condition with the interpolated recall, when the total number of presentations is constant, was significant and had a high degree of statistical reliability. Inspection of Tables III and IV substantiates the statement.

The third problem deals with the variability of the effectiveness of an interpolated recall as dependent upon the stage of learning at which the recall was inserted.

(a) When the total number of presentations was six, as in Arrangements 2L-R-4L-R and 4L-R-2L-R, the later recall yielded the higher recall score. Since the other factors were relatively constant, the difference in final recall score should be ascribed to the difference of time at which the recall was interpolated.

(b) When the total number of presentations was eight, as in Arrangements 2L-R-6L-R, 4L-R-4L-R, and 6L-R-2L-R, we found that the longer the interpolation of recall was delayed, the higher was the corresponding recall score. Although the differences were not very marked, they were rather consistent. A recall inserted after two initial presentations gave a proportionately lower score than when the recall was interpolated later.

(c) When the total number of presentations was ten, as in

Arrangements 2L-R-8L-R, 4L-R-6L-R, 6L-R-4L-R, and 8L-R-2L-R, we found the lowest score was obtained when the recall was inserted after the two initial presentations. Interpolation of the recall after four initial, successive presentations brought a result that did not fit in with the rest of the findings. In all other arrangements of learning throughout the experiment we found that a recall inserted after four initial presentations resulted in a lower final score than a recall inserted later, provided the recall came before the optimal of eight was passed. The writer did not find any explanation for this phenomenon. There was nothing during the procedure of the experiment that would have suggested this outcome. Arrangement 6L-R-4L-R had a slightly higher average than Arrangement 8L-R-2L-R; but this difference was really negligible.

(d) A comparison of Arrangements 2L-R-10L-R, 4L-R-8L-R, 6L-R-6L-R, 8L-R-4L-R, and 10L-R-2L-R indicated that the later the recall was interpolated, the higher was the corresponding final recall score if the interpolated recall came before the tenth successive initial presentation was reached. An interspersed recall after the tenth or twelfth presentation resulted in lower final scores. It is also of interest to note that a recall inserted too early in the learning stage and followed by a large number of successive presentations was not as effective as when spaced later. This series of conditions clearly indicated that eight successive trials was the optimal number of presentations after which the inserted recall was most effective.

(e) With a total of fourteen presentations, as in Arrangements 2L-R-12L-R, 4L-R-10L-R, 6L-R-8L-R, 8L-R-6L-R, 10L-R-4L-R, 12L-R-2L-R, the results gave a repetition of the facts deduced in (d). The lowest score was obtained when the recall was inserted after the two initial presentations. As the number of presentations previous to the first recall was increased up to the optimal of eight, the corresponding final scores increased. As the interpolated recall was delayed after passing this optimal, the respective recall scores became smaller. This series also brought out the fact more prominently that if the extra recall was inserted too early, it was less effective. Arrangement 10L-R-4L-R had a higher final recall score than Arrangement 12L-R-2L-R because the subjects re-

ceived four additional trials instead of two after having had the opportunity to recall. Furthermore, twelve initial presentations were not of greater effect than ten, since the optimal had been reached at eight.

The writer calls attention to the consistency of these findings which ought to be given consideration even though the statistical reliability between any two successive arrangements may not always have been substantiated by an unquestionable, or 100% true, difference. A still larger number of subjects would very likely eliminate the possible objections.

"Early" or "late" recall depended somewhat upon the total number of presentations. A recall inserted after the fourth initial trial would be thought of as "late" when comparing Arrangements 4L-R-2L-R and 2L-R-4L-R, but it would be considered "early" if one compared 4L-R-10L-R and 10L-R-4L-R. Table III shows that with one possible exception a late recall was the more economical, especially when one compared symmetrical arrangements, such as 2L-R-4L-R and 4L-R-2L-R, or 2L-R-8L-R and 8L-R-2L-R, or 4L-R-10L-R and 10L-R-4L-R, etc. A recall inserted too early gave a relatively low final score; as for example, in all conditions in which the interpolated recall occurred after the second initial trial. The tendency was, throughout, that the later the interpolated recall came, the higher the final recall score, provided that the optimal of eight was not exceeded.

In regard to the last problem, it may be repeated that on the basis of the data, the optimal number of presentations, before introducing the first recall, was eight. Additional presentations after that number did not increase the final scores unless a recall was interpolated. Other conditions being equal, a recall inserted immediately after the eighth presentation gave the highest final recall score with the one possible exception, namely Arrangement 4L-R-6L-R, which seemed to be entirely out of line with the rest of the tendencies.

Introspective reports of the subjects and observations by the experimenter while the subjects learned the material, indicated that the subjects obviously lost interest when the number of successive presentations was very long, particularly after the tenth trials. One phenomenon that was frequently observed was that the subjects would make preparations to write the answers after the early presentations; and, that the

longer the presentations would continue, the less effort was put forth by the subjects to be ready to write. After some six or seven trials the subjects would not move at all until the recall was required. Frequently the subjects expressed surprise or disappointment when an unexpected recall was requested after the two initial trials. Many reports indicated an eagerness to recall after the fifth or sixth presentation. Several persons actually asked the experimenter to permit them to recite at that time because they believed they "knew it best" at that stage of practice.

Conclusions

(1) When the number of presentations was increased and no recitation was introduced, the corresponding recall scores increased (negatively accelerated) until an optimal of eight presentations was reached. After this optimal, additional practice affected the final recall scores little.

(2) An interpolated recall increased the retention score irrespective of when it was introduced during the learning process.

(3) The effectiveness of one interspersed recall varied with the stage of learning at which it was inserted.

(4) With but the one exception an early recall was less economical than a late recall when the total number of presentations was constant.

(5) When the total number of presentations was constant, eight presentations appeared to be the optimal number of trials before introducing the first recall.

CHAPTER IV

A SUMMARY STATEMENT OF THE STATUS OF EXPERIMENTAL INVESTIGATIONS TO DATE

The Authors

Certain phases of this problem have been sufficiently investigated to justify definite factual statements. Other problems remain as yet unsettled. In any research in the future the writers suggest certain desiderata. We shall discuss each of these three topics briefly.

Facts Fairly Well Established

1. In the case of adults most of the experimental evidence indicates that the introduction of some degree of reading-recitation or "attempted" recall is more efficient than mere reading.

2. The same situation appears to be true in the case of children. However, due to less rigid control of conditions, the results cannot be so reliable as in the case of trained adult subjects.

3. The value of reading-recitation differs according to the nature of the material which is learned. The evidence indicates that reading-recitation is most effective with relatively senseless or disconnected material and least economical for sense or connected material.

4. If by recitation is meant a mere attempt to recall or reconstruct the material without including any prompting or reading, then interspersed recitations are more effective than any method of grouping.

5. There is always an optimal time for introducing the combined reading-recitation process. A certain number of preliminary pure readings are always necessary. For relatively short materials, meaningful or meaningless, the optimal number of preliminary readings seems to lie between four and eight, with an average of six.

6. A pure reading, even under the best controlled conditions and in the case of highly trained subjects, is the exception rather than the rule, after the first few preliminary readings.

All subjects tend to test themselves to some extent and in various ways.

7. Analysis indicates that the attention factor functions best during the reading-recitation process.

Some Important Unsettled Questions

1. Little is known of the relative value of reading-recitation when lengthy materials are used. The present and past work has been concerned with relatively short sense and nonsense materials.

2. Different methods of testing efficiency may yield varying results. Several methods of testing efficiency should be used and compared.

3. The problem of relative amounts retained after long intervals needs further investigation. Most of the experimental work has dealt with immediate or early recall.

4. The time spent in "searching" or trying to "anticipate" the next learning element in a series before actually getting the perceptual cue is an interesting and very important question. Too much time may be spent in vain searching. It is evident that some of that effort directed to reading-recitation would bring about more economical learning.

5. Another problem is the relation of the efficiency of the reading-recitation process to the imagery type of the individual.

6. The method of presentation may have considerable bearing upon the problem of reading in relation to reading-recitation. Little information is at hand on this matter.

7. There is some evidence that continuous reading without interspersing a recall or a reading-recitation will not increase retention after an optimal number of pure readings.

8. The time alloted for reading an element in a series may determine the optimal point at which the most economical recall or reading-recitation should be inserted.

Desiderata in Future Research Work

1. It is suggested that all experimenters define a "reading" in a uniform and strict manner. A reading should mean the passing of attention over one after another of serial learning elements with no attempt to *anticipate* the next element. The

moment any degree of anticipation takes place, a reading-recitation process is introduced.

2. The term "recitation" should signify that the subject has attempted to recall all of the material possible, but has not resorted to any perceptual cues (reading or hearing the actual elements pronounced).

3. If the experimenter wishes to speak of a combined or mixed process, he should not speak of a recitation but should speak of a reading-recitation or a reading-anticipation or a reading-prompting process. The standardization, reading-recitation, is suggested because it has been used so frequently. It should refer to the fact that the subject tried to recall the material and, when unable to get the next element, looked at his material or otherwise received a prompting.

4. For the sake of more reliable results, trained subjects who are capable of giving careful introspective reports should be used. Work with children under practical conditions may have considerable practical value but is of questionable scientific value. Whether or not, for example, a subject is engaged in a pure reading can only be determined by a study of the subject's introspections.

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